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Recommended design for a pilot fleet communication program for the Hawaii longline tuna and swordfish fisheries

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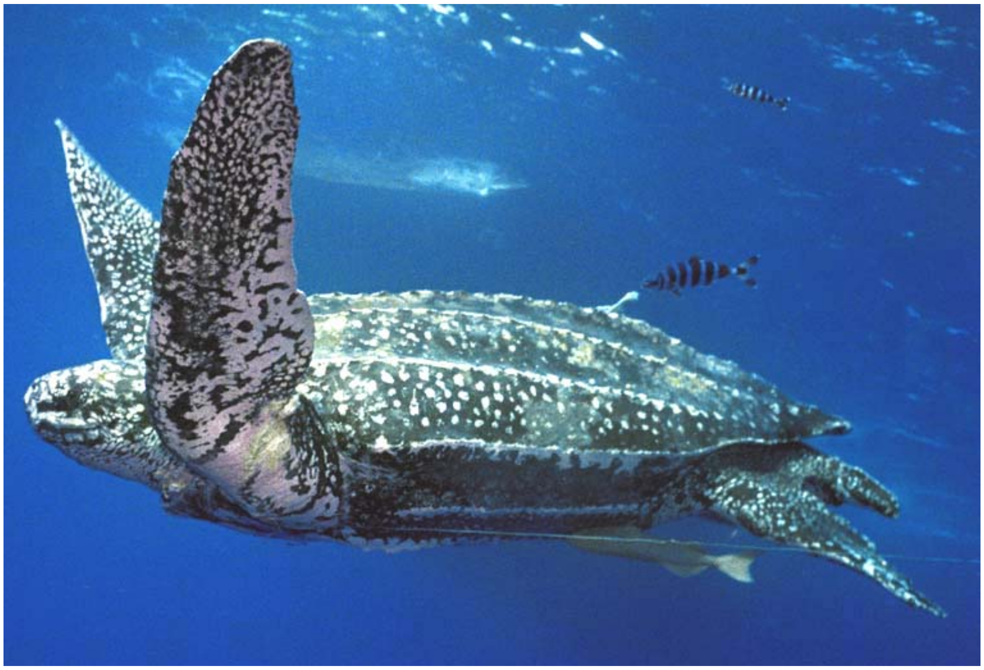

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SUMMARY

Instituting a fleet communication system to report near real-time observations of bycatch hotspots enables a commercial marine fishery to operate as a coordinated “One Fleet” to substantially reduce fleet-wide capture of protected bycatch species, including fish, seabirds, sea turtles, and marine mammals. This benefits the bycatch species per se, reduces waste, and can provide economic benefits to industry by reducing the risk of exceeding government-established seasonal bycatch thresholds as well as avoiding possible future declines in target species catch resulting from bycatch of juvenile and undersized individuals. We describe alternative designs for fleet communication programs to reduce fisheries bycatch. Case studies are included for communication programs of the U.S. North Atlantic longline swordfish fishery, U.S. North Pacific and Alaska trawl fisheries, and U.S. Alaska demeral longline fisheries. Available information from these case studies supports the inference that they have substantially reduced fisheries bycatch and provided large economic benefits that outweigh relatively nominal operational costs. Recommendations for design of a pilot fleet communication project are made for the Hawaii pelagic longline tuna and swordfish fisheries to reduce bycatch of sea turtles and albatrosses.

1. INTRODUCTION

Bycatch in marine fisheries is an increasingly prominent international environmental, social, and economic issue (Alverson et al. 1994; IUCN 1996a,b, 2000a,b; Hall et al. 2000; Cook 2001; Dobrzynski et al. 2002; Environmental Justice Foundation 2003; FAO 1999a,b,c, 2004a,b; Gilman 2001, 2005a). The issue is addressed as a component in a growing number of broad international resolutions, including Agenda 21 (1992); the Cancun Declaration (1992); UN General Assembly Resolutions 49/118 (1994) and 50/25 (1995); the Rome Consensus on World Fisheries (1995); the UN Food and Agriculture Organization International Code of Conduct for Responsible Fisheries (1995); and the Kyoto Declaration and Plan of Action (1995) (Haward et al., 1998; Hall et al., 2000; Gilman, 2001).

Bycatch, incidental catch that is discarded dead or released injured to a degree that delayed mortality will soon occur (Hall et al., 2000), can harm ecosystems and economic viability. Some bycatch species of seabirds, sea turtles, marine mammals, sharks, other finfish species are particularly sensitive to increased mortality above natural levels because of their life history traits, including their being long-lived, having delayed maturity, and having low reproductive rates (e.g., Gilman and Freifeld, 2003). Other possible ecosystem effects of bycatch include altering biodiversity by removing top predators and prey species at unsustainable levels, and altered foraging strategies by species that learn to take advantage of discards (Hall et al., 2000). Economic effects on industry from bycatch include the imposition of a range of restrictions, closed areas, embargos, and possible closures; interference between fisheries, where bycatch in one fishery reduces target catch in another; and if bycatch in a fishery results in mortality of juvenile and undersized individuals of a commercial species before the finfish or shellfish reach their optimal size, this can adversely affect future target species catch levels (Hall et al., 2000). And bycatch is a social issue where discarding millions of tons of fish is a wasted food source as well as a waste of animal lives. While global commercial marine fisheries bycatch estimates are based on large assumptions due to incomplete data for many fisheries, including unobserved bycatch such as in abandoned and lost gear, Alverson et al. (1994) estimated that in 1994 about 27 million metric tons (27% of the world catch), ranging between 17.9 and 39.5 million tons, of fish per year was discarded at sea. FAO (1999c) estimated that 1998 global marine fisheries fish discards totaled 20 million metric tons.

Prominent bycatch issues include dolphins and porpoises in purse seines and driftnets; fish discards in shrimp trawls; seabird, sea turtle, marine mammals, and shark bycatch in longlines, purse seines, gillnets, and trawls (Leadbitter 1999; Hall et al. 2000). For instance, hundreds of thousands of seabirds, including tens of thousands of albatrosses, are caught annually in longline fisheries worldwide, posing a critical global threat to some albatross and large petrel populations (Brothers *et al*. 1999; Gilman 2001; Gilman *et al*. 2005a). Cumulative turtle mortality in pelagic longline gear worldwide poses a priority threat to sea turtles, in particular, to leatherback (*Dermochelys coriacea*) and loggerhead (*Caretta caretta*) sea turtles (FAO 2004a,b; Gilman et al. 2005b).

There is anecdotal information that, in longline fisheries where turtle interactions are relatively rare events, if a vessel catches a turtle, moving the vessel from the grounds where the turtle capture occurred before making another set will reduce the chance of having another turtle interaction, based on observations in the U.S. Hawaii and North Atlantic longline swordfish fisheries, and Canadian Northwest Atlantic longline swordfish and tuna fisheries (Javitech 2002 and 2003; Gilman et al., 2005b). In these fisheries, longline vessels could move to new grounds after observing a turtle interaction and a fleet communication program would enable this vessel to inform the rest of the fleet to avoid the area where they interacted with a turtle. Similarly, fleet communication can also assist fleets abate problematic finfish, shellfish, seabird, and marine mammal bycatch by avoiding bycatch hotspots (Gauvin et al. 1995; Haflinger 2005).

Fleet-wide communication protocols can report real-time observations of hotspot fishing grounds where bycatch rates are high so that vessels in the fleet can avoid fishing in the area. Fleet communication is a voluntary form of area and time closures to reduce marine fisheries bycatch. Fleet communication programs have the potential to allow commercial fisheries to operate as a coordinated "One Fleet" to significantly reduce the fleet's bycatch levels and rates. In the short term this could allow an industry to reduce the risk of exceeding government-established seasonal bycatch thresholds. And in the long term this could help prevent a decline in the capture of target species in fisheries where bycatch of juvenile and undersized individuals of commercial species is problematic.

Case studies are included for fleet communication programs to manage fisheries bycatch for the U.S. North Atlantic longline swordfish fleet, U.S. North Pacific and Alaska trawl fisheries, and U.S. Alaska demeral longline fisheries. We describe alternative approaches for fleet communication programs to reduce fisheries bycatch. We also put the concept of fleet communication programs into context by describing the broad range of strategies for reducing marine fisheries bycatch. The Hawaii pelagic longline swordfish and tuna fisheries are used as examples for designing a pilot fleet communication program to manage sea turtle and seabird bycatch.

2. CASE STUDIES OF FLEET COMMUNICATION PROGRAMS

2.1. U.S. North Atlantic Longline Swordfish Fishery "Captain's Daily Communication"

Primary information sources for this case study are John Watson, U.S. National Marine Fisheries Service Southeast Fisheries Science Center, personal communication, 11 August 2004; Nelson Beideman, Blue Water Fishermen's Association, Inc., personal communication, 11 August 2004; Shah et al. (2004); and Watson et al. (2004).

In 2001 the Blue Water Fishermen's Association voluntarily established and manages a fleet communication program for the U.S. North Atlantic longline swordfish fishery, primarily to reduce loggerhead and leatherback sea turtle bycatch. The formal daily captain communications ended in 2003 when an experimental fishery research project ended. However, alerting members of the fleet about grounds to avoid where turtle bycatch is a high risk is now a standard part of the information shared between vessels, so the communication program is still informally in operation.

Vessels use short (VHF) and long range radio and e-mail to communicate. Information communicated amongst the fleet incudes sea turtle encounters, sightings of clusters of sea turtles, and specific oceanographic features. The fleet-wide communication protocol enabled vessels to avoid fishing on the warmer side of oceanographic fronts and tight bends in the edge of an oceanographic front, where fishers found relatively high interaction rates with turtles.

There was enormous peer pressure among fishers to avoid turtle interactions to ensure a government threshold was not exceeded. An area of over 7.7 million km^2 in the western North Atlantic, which includes the productive Grand Banks, had been partially closed to the U.S. pelagic longline fleet since 2000, and completely closed since 2001 due to concerns over turtle bycatch (U. S. National Marine Fisheries Service 2000, 2001a,b). All of the vessels participating in the fishery during the time period when the formal fleet communication program was in operation from 2001-2003 were part of a government research experimental fishery to test the effectiveness of new gear (circle hooks) at reducing turtle injury and capture, and there was a limit on the total number of turtle takes for the fleet during this experiment. All of the vessels participating in the experiment were members of the Blue Water Fishermen's

Association, facilitating having all of the vessels participate in the voluntary communication program.

Turtle bycatch-per-unit-of-effort on traditional J hooks during operation of an experimental fishery that used both traditional J and new circle hooks, conducted between 2001 and 2003, when industry was implementing the fleet communication program, was reduced by 50% compared to observer program records of turtle bycatch-per-unit-of-effort on J hooks prior to 2001 before the fleet communication protocol was instituted (Shah et al., 2004; Watson et al., 2004).

There as been no assessment of the economic benefits and costs from instituting the fleet communication program. However, the fleet communication program is hypothesized to allow the fleet to reduce turtle captures by half. If turtle captures exceed limits established under the U.S. Endangered Species Act, fishing effort could be restricted or the entire fishery could be closed. The fishery is worth US $40 million per year. Captains are in regular frequent communication via radio and e-mail, so there is minimal additional cost for the transfer of information about sea turtle bycatch.

2.2. U.S. Alaska Demersal Longline Fisheries Fisheries Information Services-Managed Fleet Communication Program

Primary information sources for this case study are Janet Smoker, Fisheries Information Services, personal communication, 17 January 2005; Fitzgerald et al. (2004); Williams and Chen (2004); and U.S. North Pacific Fishery Management Council (2004).

In 1992 the North Pacific Longline Association voluntarily instituted a fleet communication program by hiring a private company, Fisheries Information Services, to manage fleet communication to reduce halibut bycatch, and in 1999 added fleet communication to reduce the seabird bycatch in Alaska demersal longline fisheries for freezer-longline vessels. These 64 to 74 active vessels target Pacific cod, Greenland turbot, and sablefish. The fleet communication program is still in operation.

Currently, observer program raw data is delivered to the U.S. National Marine Fisheries Service via radio. U.S. National Marine Fisheries Service observer data include catch data for each observed vessel: observations of number and weight of target and bycatch species hooked, locations of set deployment and retrieval, and fishing effort. Fisheries Information Services accesses the government observer database over the internet and sends compiled reports to managers and, if requested, to skippers, via e-mail.

Fisheries Information Services e-mails weekly “report cards” to the fleet and provides detailed information on individual boats’ bycatch to each vessel owner. Weekly information includes raw numbers of birds caught and weight of halibut bycatch for each vessel and totals for the entire fleet. Vessel codes rather than vessel names are used in the report in order to protect confidentiality. However, all vessels have provided their codes to a fishery organization (the North Pacific Longline Association), which is then able to contact individual vessels whose bycatch levels and rates are high. This separation of the analytical and “enforcement” parts of the program is deemed critical. Fisheries Information Services also produces semi-annual seabird bycatch reports that compile bycatch-per-unit-of-effort by individual boats, fishing areas, targets, and fleet summations. These are usually completed 1-2 months after closure of winter and fall cod seasons. Fisheries Information Services also develops maps showing halibut and bird bycatch hotspots (vessel names are not attached to this data to protect confidentiality). This information is infrequently distributed during the fishing season as some members of the fleet want to avoid disclosing their fishing locations. Maps showing seabird bycatch locations (by species) for the same month of the previous year are provided to fishery participant prior to each month.

Since 1990 government-established annual caps on halibut mortality for hook-and-line cod fisheries and "other" (turbot) fisheries in the Bering Sea and Aleutian Islands and cod fisheries in the Gulf of Alaska have been in place. Reaching any of these thresholds results in closure of all hook-and-line fishing for those species and areas for the remainder of the year. There is also an annual cap on the number of Short-tailed Albatrosses than can be captured by the Alaska demersal longline fleet. If this threshold is exceeded, the fleet could be subject to additional restrictions and possibly closure.

All of the vessels in the freezer-longline vessels in the Alaska demersal longline fleet participate in the fleet communication program. During the first four years of operating the halibut bycatch avoidance program, the number of participants increased from 14 to 28 boats. When the seabird bycatch avoidance program was added in 1999, gradually over several years, all of the remaining vessels in the freezer-longliner fleet joined the fleet communication program. There are dozens of smaller hook and line boats that fish for Individual Fishery Quota sablefish a few weeks to months each year, which also incidentally catch seabirds, but have infrequent observer coverage, and have declined to participate in the fleet communication program.

Because the fleet communication program was implemented concurrent with the introductions of additional measures to reduce halibut and seabird bycatch, including new practices for the "careful release" of halibut, and bird-scaring tori lines for seabirds, this prevents a determination of the single factor effect of instituting the fleet communication program on trends in bycatch rates. However, during a period of seven years when about ten boats did not participate in the fleet communication program, the average halibut bycatch rates of non-participating boats were 10-30% higher than participating vessels, supporting the inference that the fleet communication program contributed to reducing halibut bycatch for participating vessels. Analysis also shows that fishing effort moved away from bycatch hotspots after warnings were issued to the fleet.

The bycatch mortality rate of halibut for Bering Sea and Aleutian Islands cod fishery decreased 33% from 1992 (the year the fleet communication program to address halibut bycatch was initiated) to 1995, and continues to decline, but more slowly (Williams and Chen 2004). The Bering Sea and Aleutian Islands cod fishery has not been closed due to exceeding its halibut bycatch cap since 2001.

Seabird bycatch rates and total annual catch has been decreasing in recent years: over 24,000 seabirds were caught in 1998 (the fleet communication program for seabirds was initiated in 1999) at a rate of 0.14 seabird captures per 1000 hooks, and fewer than 5,000 were caught in 2003 at a rate of 0.02 seabird captures per 1000 hooks (U.S. North Pacific Fishery Management Council 2004). It is not possible to identify contributing causes for this decline in seabird bycatch, but vessels avoiding seabird bycatch hotspots may have played a role. Many captains and vessel owners expressed surprise when they first were informed about their boat's seabird bycatch levels, and most of these vessels subsequently reduced their seabird bycatch rates. Owners of some of the boats that receive warnings from the North Pacific Longline Association about their having high bycatch contact Fisheries Information Services for more information and advice to help them reduce their bycatch.

In 2003 the Bering Sea and Aleutian Islands hook and line catcher-processor cod fishery was worth US $67.9 million ex-vessel. The open-access fishery lasted 193 days in 2003, making the average daily value of the fishery more than US $0.5 million. Fisheries Information Services charges the fleet US $60 per observed vessel per week. Vessel communication costs are an additional operational expense for participating vessels. However, because Fisheries Information Services reports are typically attached to existing e-mail message traffic between companies and their boats, this cost is likely nominal. The cost for onboard observers, without which the program could not successfully operate, is an additional expense, but the observer program is mandatory and a cost that would still exist without the communication program.

2.3. U.S. North Pacific and Alaska trawl fisheries Sea State, Inc. – Managed Fleet Communication Program

Primary information sources for this case study are Karl Halfinger, Sea State, Inc., personal communication, 25 January 2005; Gauvin et al. (1995); and Haflinger (2005).

In 1994, the U.S. Washington, Oregon, and Alaska trawl fisheries, which target Alaska pollock, Pacific cod, Bering Sea rock sole, Bering Sea yellowfin sole, Atka mackerel, Pacific whiting, and scallops, voluntarily hired a private company, Sea State, Inc., to establish and manage a fleet communication program. The fleet communication protocol aims to reduce the bycatch of chum and chinook salmon in pollock fisheries; halibut in flatfish and cod fisheries; several species of crab in flatfish, cod and scallop fisheries; and several species of rockfish in pollock, mackerel and whiting fisheries. The fleet communication program is still in operation. Participation in the fleet communication program has always been high, and has now reached 100% of vessels for participating fleets.

Methods used for fleet communication are e-mail via several satellite systems and the Northwest Groundfish Observer Program, short catch logs via satellite-based vessel monitoring systems (VMS), and occasional phone calls. Most of the trawl fisheries have high onboard observer coverage and send their observer data directly to Sea State. The observer data includes bycatch data for each vessel on the number of bycatch species hauled aboard, location where bycatch species were hauled aboard, and fishing effort. Some smaller trawl fisheries that have relatively low observer coverage submit their own observations of bycatch to Sea State. Sea State analyzes the bycatch data to produce maps, tables, commentary, and other products providing information on the location of bycatch hotspots, and daily sends these products, usually via e-mail, to the fleet. Most coastal catcher vessels, which cannot receive email attachments, receive copies of the Sea State materials when they are in port. These coastal vessels' trip lengths are relatively short, lasting 1-3 days, so the bycatch information is still pertinent when they receive it. When necessary, critical bycatch information can be sent to these vessels through their processors. Vessels also communicate bycatch hotspot information to each other using their radios.

The pollock fishery faces seasonal and area closures if government-established salmon bycatch caps are reached. The flatfish and scallop fisheries face seasonal area closures if halibut or crab bycatch caps are reached. Mackerel fisheries face seasonal closure if rockfish bycatch limits are exceeded.

Some of the fleets, such as the trawl pollock fishery, have formal elaborate agreements in place between the individual vessels related to the operation of the fleet communication program. Other fleets, with fewer boats, tend to adapt to the information provided by Sea State through informal agreements between the vessels developed ad hoc on the fishing grounds. The informal agreements are often discussed in skippers meetings before the season begins. Most boats belong to a trade organization that organizes pre-season meetings. Sea State has come to anticipate the occurrence of bycatch problems at certain times of the year, enabling some industry decisions to be made before the season begins. If, for example, crab bycatch rates are above three crabs per metric ton of fish, then the fleet has agreed to move south of 56 degrees N. latitude in the winter rock sole fishery. Other responses to bycatch levels are not made in advance, but the fleets are typically small enough that the skippers communicate when they receive information on bycatch levels and decide ad hoc how to respond.

No formal evaluation of the effectiveness of the Sea State-managed fleet communication programs has been conducted. Because the abundance of bycatch species is not known, trends in bycatch rates do not indicate the effectiveness of the fleet communication program. All of the bycatch species, excluding rockfish, that Sea State is working with exhibit large year class variations, so without specific surveys at the time and area the fishery is operating, it is difficult to determine program effectiveness.

The fleet communication program is worth on the order of millions of dollars to the participating fleets. Gross revenue to a boat in the rock sole fishery is about US $50,000 per day. The fleet communication program has likely enabled the fleets to operate days and perhaps weeks longer in some years. Fuel costs alone mount into the millions of dollars in the pollock fishery, so avoiding time and area closures, which would increase distances from port to fishing grounds, is economically important.

Sea State charges an average of $2,000 per year per boat for administration of the fleet communication program and data analysis. Participating vessels are required to use VMS and e-mail regularly, so additional communication costs from participating in the Sea State program are nominal. The cost per vessel to transmit observer data is roughly estimated to be US $200 per year.

3. ALTERNATIVE DESIGNS FOR "ONE FLEET" COMMUNICATION PROGRAMS

Four central parameters need to be considered when designing a new fleet communication program:

- <u>Technology for communication</u>: The fleet communication program can use e-mail through satellite-based vessel monitoring systems, e-mail through other satellite-based systems, radio, phone, fax, or a combination of these technologies to facilitate communication between vessels and through a designated hub. Depending on the provider, costs for vessel use of satellite-based e-mail can be charged by server time, or by the character in the body of messages plus the size of attached files.

- Observer program: It may be possible to make use of onboard observer data to facilitate implementation of the "One Fleet" program. Otherwise, vessel skippers or crew would need to collect and transmit the bycatch data.
- Manager: Options for the organization that manages the fleet communication program include a fishery association if one exists, relevant fishery management authority, or a private company. In most fisheries, government agencies do not have resources for requisite data processing and transmission of bycatch information in a suitable time frame suitable to facilitate effective bycatch avoidance (Gauvin et al. 1995).
- Program policies: Advice from relevant experts is needed to determine how long an identified bycatch hotspot should be avoided and how large an area around the hotspot should be avoided to aid in developing policies for implementation of the fleet communication program.

4. PUTTING FLEET COMMUNICATION PROGRAM'S INTO CONTEXT: ALTERNATIVE STRATEGIES TO MANAGE FISHERIES BYCATCH

Fleet communication is one of a large number of available strategies to manage commercial marine fisheries bycatch. Other categories of bycatch reduction strategies are described in this section. Fleet communication programs can be implemented in combination with these other strategies to sustainably manage fisheries bycatch.

(a) Formal Constraints: National-level legal, regulatory, and policy-derived formal constraints, combined with an effective surveillance and enforcement program, can promote industry compliance with laws, rules, and policies to minimize fisheries bycatch (Convention on Biological Diversity, 1996). For instance, bans on discards, reductions in fishing effort, limits on total seasonal bycatch levels or individual vessel bycatch levels, seasonal or area closures, mandatory use of bycatch avoidance techniques (such as restricting fishing to nighttime to reduce seabird capture), and required marking and reporting of lost gear are regulatory tools for managing fisheries bycatch (Leadbitter 1999; Hall et al., 2000; Gilman et al., 2005a). Another strategy is for fishery management authorities to create a fee and exemption structure for marine fisheries bycatch, applicable to individual vessels or to an entire fleet, similar to a "polluter pays" system (Gilman et al., 2002). Alternatively, the fee structure could provide a positive reward-based incentive, where a higher subsidy, lower permit or license fee, or lower taxes apply, and a positive image is portrayed when a vessel or fleet meets bycatch standards. For example, the Commission for the Conservation of Antarctic Marine Living Resources permits vessels that have demonstrated compliance with management measures to initiate the fishing season earlier than other vessels in the fishery (personal communication, Graham Robertson, Australian Antarctic Division and member, CCAMLR Ad Hoc Working Group on Incidental Mortality Associated with Fishing, December 2002). Additionally, the threat of the closure of a fishery if bycatch performance standards are not met provides a strong incentive for industry compliance to minimize bycatch.

(b). Regional and international accords, regulations, and policies: Multilateral accords that address fisheries bycatch, such as the United Nations Implementing Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks, can obligate national governments to adopt enabling legislation to manage these interactions (Gilman, 2001). Regional organizations can adopt regulations and policies to manage interactions between fisheries and sensitive species for compliance by member nations, such as the Commission for the Conservation of Antarctic Marine Living Resources' Conservation Measures (Haward et al., 1998; Gilman, 2001). Multilateral bodies can adopt advisory policies to encourage fishing nations to sustainably manage fisheries bycatch, such as the United Nations Food and Agriculture Organization's non-binding *International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries* (FAO, 1999a).

(c) Marine protected areas, area and seasonal closures: Area and seasonal closures are management tools that can complement employment of other strategies to reduce bycatch. Closed areas can have substantial adverse economic effects on industry, but remain an available tool to fishery managers if alternative effective methods are not available. It may also be a more desirable option than a closed fishery.

However, resource use restrictions of a marine protected area may displace effort to adjacent and potentially more sensitive and valuable areas, especially if an effective management regime does not exist for these other areas (Gilman 2002). For instance, closures such as occurred in the Northwest Atlantic for the U.S. pelagic longline swordfish fleet to address sea turtle bycatch may have had negative consequences for some sea turtle populations by displacing longline effort to alternative grounds such as the South Atlantic (Kotas et al. 2004). And, for example, the consequence of displacing longline fishing effort from an area closed off Newfoundland due to concerns with bycatch of sea turtles was an increase in catch of 11 shark species and 10 depleted fish species (Baum et al., 2003). Instituting a closure for one longline fleet may also result in increased effort by another nation's longline fleet with fewer controls to manage bycatch. For instance, during a four-year closure of the Hawaii longline swordfish fishery due to concerns over bycatch of sea turtles, swordfish supply to the U.S. marketplace traditionally met by the Hawaii fleet was replaced by imports from foreign longline fleets, including from Mexico, Panama, Costa Rica, and South Africa, which have substantially higher ratios of sea turtle captures to unit weight of swordfish catch and less stringent or no measures to manage seabird bycatch (Gilman and Freifeld 2003; Bartram and Kaneko 2004; Sarmiento 2004).

Establishing protected areas containing nesting or breeding colonies of protected resources and adjacent waters within a nation's Exclusive Economic Zone is potentially an expedient method to reduce fisheries bycatch. For instance, to avoid interactions between the Hawaii-based longline fishery and the endangered Hawaiian monk seal (*Monachus schauinslandi*), the U.S. Government prohibits longline fishing within 50 nautical mile around the Northwestern Hawaiian Islands, which prevents seabird and longline interactions close to albatross colonies (U.S. Department of the Interior and U.S. Department of Commerce 2000). Also, most of the Northwestern Hawaiian Islands have been part of the U.S. National Wildlife Refuge System for the past century, where all commercial fishing activities are prohibited in nearshore waters, providing a small buffer for the more than 14 million nesting Pacific seabirds of 19 species, where 98 percent of the world's population of Black-footed Albatross and 99 percent of the world's population of Laysan Albatross nest (U.S. Fish and Wildlife Service 1999).

However, establishing high seas marine protected areas to restrict fishing in bycatch species' foraging areas and migration routes, which would require extensive and dynamic boundaries defined in part by the location of large-scale oceanographic features and short-lived hydrographic features such as eddies and fronts, and would require extensive buffers (Hyrenbach et al. 2000), may not be a viable short-term solution to abate acute fisheries bycatch problems (Thiel and Gilman 2001). This is due in part to the extensive time anticipated to resolve legal complications with international treaties, to achieve international consensus and political will, and to acquire requisite extensive resources for surveillance and enforcement to implement high-seas marine protected areas (Thiel and Gilman 2001).

International bodies have created marine protected areas on the high seas: The International Whaling Commission declared the Indian and Southern Oceans as no-take sanctuaries for whales, covering 30 percent of the world's oceans mostly on the high seas. Conventions governing international shipping have designated large areas of the ocean that include high seas as Special Areas where stringent restrictions apply regarding discharges from ships. Furthermore, under the United Nations Convention on the Law of the Sea, the International Seabed Authority could protect areas from minerals extraction beyond national jurisdiction where there is a risk of harm to the marine environment (Kelleher 1999). Recent developments within the framework of the United Nations Convention on the Law of the Sea and associated conventions may make it possible in the future to restrict fisheries activities on the high seas that are shown to undermine marine conservation (Kelleher 1999). However, it is unlikely that this treaty or the other 300 treaties involving the seas will be able to be used to establish areas closed to fishing on the high seas quickly enough to address the acute threat to several threatened species, such as species of sea turtles and seabirds, from interactions with fishing gear.

(d) Improved practices for handling and release: Reducing injury and incidence of post-release mortality for species to be released alive contributes to reducing bycatch. For instance, there are prescribed best practices for seabird and sea turtle handling and release (Gilman and Elliott, 2002; Epperly et al. 2004; Gilman 2004a) and for finfish and shellfish handling and release (Leadbitter 1999).

(e) Changes in fishing gear and methods: For example, fishing technology to manage seabird and sea turtle bycatch in longline fisheries include the following six categories (Brothers *et al.* 1999a; Gilman *et al*., 2005a,b):

- Alter fishing practices to avoid peak areas and periods of turtle and bird foraging (e.g., night setting, area and seasonal closures, deeper setting);
- Reduce the detection of baited hooks by birds and turtles (e.g., blue-dyed bait, shielded deck lights, shielded lightsticks);
- Limit bird and turtle access to baited hooks (e.g., side-setting, underwater setting devices, thawed bait, addition of more weight closer to hooks, bait-casting

machines, device added near or over the baited hook to physically protect the baited hook from turtles);

- o Deter birds and turtles from taking baited hooks (e.g., bird-scaring line with streamers, acoustic deterrents, water cannon, towed buoy);
- o Reduce the likelihood of hooking turtles and birds (use larger hooks; use a "G" shaped circle hook, which has a relatively small gap between the hook's point and shaft; use large fish for bait instead of squid); and
- o Reduce the attractiveness of baited hooks to birds and turtles (e.g., artificial lures, unpleasant smell and taste).

(f) Eco-labeling: Consumer demand can alter industry behavior. A fishing industry can pursue certification or accreditation from an eco-labeling certification program. The incentives to industry are a market-based incentive to increase demand and for and value of their products, and a social incentive to receive recognition from the public for complying with accepted norms (Wessells et al., 1999; Gilman, 2002). Eco-labeling can serve as an effective marketing tool for a fishing industry, when properly managed. For instance, certification under an eco-labeling scheme can be used as a marketing tool to develop and market an image and product differentiation, through advertising, sales promotion, public relations, direct marketing, and media coverage. A company can differentiate their seafood products as coming from a fishery that follows internationally accepted practices to ensure environmental sustainability from other industry's seafood, which may not come from fisheries that adhere to the same environmental standards. This is a form of cause-related marketing, a proven means to promote recognition and develop a positive company image and reputation.

For instance, the Marine Stewardship Council is an international organization that has a certification program for seafood and uses a product label to reward environmentally responsible fishery management and practices. Principles and criteria adopted by the Marine Stewardship Council, used to assess the suitability of fisheries for certification, are intended to ensure that certified fisheries are sustainable and well managed. Principles attempt to avoid over-fishing, prevent adverse ecosystem impacts, and ensure a responsible management framework is in place that leads to sustainable fishing practices (Marine Stewardship Council, 1998).

Seafood score cards, which recommend that consumers purchase only species that are assessed as being from sustainable fisheries, are another eco-labeling method that may provide an economic incentive for industries to meet criteria for a sustainable fishery. For instance, the *Seafood Lover's Almanac* ranks popular seafood based on various criteria, including life history, management record, habitat health, and bycatch (Lee, 2000).

(g) Industry self-policing: A longline industry can create a program where information for individual vessel bycatch levels, compliance with relevant regulations, and other relevant information, is made available to the entire industry. This method is especially effective where regulations contain industry-wide penalties (such as threat of reduced length of fishing season, closed areas, or complete fishery closure) if annual bycatch rates or mortality levels of specific species are exceeded by the fleet. This self-policing program uses peer pressure from within the industry to criticize bad actors and publicly acknowledge good actors. For example, the North Pacific Longline Association initiated a seabird report card system among its members in 2000. This system uses each individual owner's access to real-time bycatch data from their vessel. Data are available from the government North Pacific Groundfish Observer Program electronic reporting system. The longline association members entered into agreements to share seabird take information and employed a private company, Fisheries Information Services, to access the data and provide performance summaries, which link seabird takes to individual vessels. Fisheries Information Services contacts vessels with high seabird bycatch levels while the vessel is still at sea so the vessel can act immediately to try to rectify their high bycatch (Fitzgerald et al. 2004).

(h) Industry awareness-raising and capacity-building: An awareness-raising and capacity-building program can help industry develop the drive and knowledge to minimize bycatch by raising longline fishers' awareness of the problem and building capacity to implement practicable solutions. Approaches include producing and distributing awareness-raising publications, holding workshops and training for fishermen, and developing voluntary codes of conduct. For example, a non-governmental organization called SeaNet has been working with Australian commercial fisheries since 1999 to deliver environmental extension services and to help facilitate change to augment the seafood industry's ecological sustainability, and is working with Australia's Eastern Tuna and Billfish Fishery to develop an industry Code of Practice, which will recommend standards for responsible fishing (SeaNet, 2002). Where resolving a bycatch problem can be cost-saving or even have operational benefits for an industry, educational initiatives that make fishers aware of how much prescribed changes can benefit them can be influential. For instance, educational materials have estimated a vessel's potential increase in revenue from reducing loss of bait to seabirds (Brothers, 1995a,b) and describe substantial operational benefits to be achieved from converting to a modified deck design for side setting for pelagic longlining that substantially reduces seabird bycatch (Gilman, 2004b).

5. PILOT HAWAII LONGLINE "ONE FLEET" PROGRAM

A One Fleet communication program could assist the HawaII longline swordfish and tuna fisheries to reduce bycatch of sea turtles and albatrosses. Both of these fisheries are subject to seasonal caps on the number of sea turtle interactions (U.S. National Marine Fisheries Service, 2004). The Hawaii longline swordfish fishery was closed for over four years and is now subject to strict management measures, including prescribed use of large circle hooks and fish bait, restricted annual effort, caps on turtle captures, and 100% onboard observer coverage, as a result of concerns over turtle interactions (U.S. National Marine Fisheries Service 2004). If a seasonal limit on turtle interactions is reached, the fishery is closed for the year, and if a threshold is exceeded, federal resource management agencies consult to determine if additional restrictions on the fishery are warranted. Furthermore, the Hawaii longline swordfish and tuna fleets are authorized to annually take, through injury or mortality, one federally listed endangered Short-tailed Albatross (*Phoebastria albatrus*) (U.S. Fish and Wildlife Service 2004). If two Short-tailed Albatrosses are observed to interact with gear of Hawaii longline vessels in a single year, this could result in closure of the fleet. Instituting a One Fleet communication program could help the Hawaii longline fleet quickly communicate a vessel's observations of the location of fishing grounds where bycatch of protected species is high so that other vessels in the fleet could avoid these bycatch hotspots and avoid possible seasonal closure and addition of management restrictions.

The Hawaii longline swordfish fleet has resulted in the majority of seabird and sea turtle captures. The tuna fleet causes an order of magnitude fewer bird and turtle mortalities primarily as a result of the location of fishing grounds and gear differences (Gilman et al. 2003, 2005b). Therefore, the Hawaii Longline Association may consider instituting a "One Fleet" communication protocol at least initially only for the fleet's swordfish vessels. However, the Hawaii longline tuna fleet reached its seasonal limit on takes of olive ridley sea turtles (*Lepidochelys olivacea*) in 2005, which may result in the promulgation of additional regulatory conservation measures, such as expanded testing of the efficacy of circle hooks and setting gear below 100 m. This presents the industry with an incentive to include the Hawaii longline tuna fleet in the pilot fleet communication program.

The Hawaii pilot fleet communication program would be a voluntary initiative of the Hawaii Longline Association. The program could use radio for communication between vessels and e-mail via VMS for vessels to communicate to a designated hub and for the hub to send out daily fleet-wide messages of the location of turtle and bird bycatch hotspots. Furthermore, the Hawaii Longline Association could request to formalize an arrangement with the U.S. National Marine Fisheries Service to access observer data, including the number of each species caught and location where the species were caught. The central hub would process the individual vessel's daily bycatch reports to create a map of bycatch hotspots, to be distributed daily to all vessels in the fleet participating in the program. Either the Hawaii Longline Association or a hired private company could manage the fleet communication program. A private company might charge between US $2,000 - $3,000 per vessel per year to administer the program. Communication costs would be about an additional $250 per vessel per year to participate in the program.

The Hawaii Longline Association could request technical assistance from the U.S. National Marine Fisheries Service and Western Pacific Regional Fishery Management Council for scientifically-based recommendations on minimum area and time period to avoid identified seabird and sea turtle bycatch hotspots. In the interim, the Hawaii Longline Association should develop an agreed policy on these voluntary protocols, based on fishers' experiences.

It is not yet known how likely it is that the Hawaii longline swordfish and tuna fleets will annually exceed seasonal sea turtle bycatch limits, making it difficult to assess if economic benefits from instituting a "One Fleet" protocol, resulting from enabling the fleet to operate for a longer time period, will outweigh economic costs from managing the fleet communication program. Furthermore, it might not be possible to definitively determine the effect of instituting the fleet communication program on sea turtle and seabird bycatch rates, because there might not be a suitable control for comparison. Historical bycatch rates would not provide a suitable comparison because the fleet is now using different technological methods designed to minimize seabird and sea turtle bycatch. Furthermore, comparison of bycatch rates from different time periods can be confounded by numerous variables, including weather, seabird and turtle behavior, fishing practices, location of fishing grounds, and consistency in observer methods (Gilman et al., 2005a). However, if some of the Hawaii longline vessels opted not to participate in the fleet communication program, a comparison of bycatch rates of participating and non-participating vessels could provide an understanding of the effect on bycatch rates from this single factor, assuming that there are no other substantial differences between the two categories of vessels. This type of analysis was possible for the Alaska demersal longline fisheries fleet communication program over a seven-year period. Non-monetary benefits to the Hawaii longline industry from instituting a "One Fleet" program to reduce turtle and bird bycatch could be substantial, such as from positive media coverage and other values not described by established monetary indicators (Dixon and Sherman, 1990).

6. DISCUSSION AND CONCLUSIONS

During a period of seven years when some vessels were not participating in the Alaska demersal longline fleet communication program, the average halibut bycatch rates of non-participating vessels were 10-30% higher than participating vessels, supporting the inference that the fleet communication program reduced halibut bycatch rates. Turtle bycatch rates in the U.S. North Atlantic longline swordfish fishery on traditional J hooks during a research experiment between 2001 and 2003, when industry was implementing a fleet communication program, was 50% lower than turtle bycatch rates on J hooks prior to 2001 before the fleet communication program was instituted (Shah et al., 2004; Watson et al., 2004), also supporting the inference that implementation of the fleet communication program reduced bycatch rates. These two cases assume that there were no significant differences between the vessels that would affect bycatch rates other than participating versus not participating in the fleet communication program. Inter-annual differences and other possible confounding factors prevent definitive conclusions about the efficacy of the U.S. North Atlantic longline swordfish fishery fleet communication program. Comparison of bycatch rates from different time periods can be confounded by numerous variables, including weather, turtle behavior, fishing practices, location of fishing grounds, and consistency in observer methods (Gilman et al., 2005a). For instance, there are annual and decadal oscillations in oceanographic conditions (e.g., Lehodey et al. 1997) that could alter turtle foraging behavior and interactions with fishing gear.

Available information from three case studies of fleet communication programs indicates that economic benefits likely substantially outweigh costs.

Design of a pilot fleet communication program for the Hawaii longline fleet could provide information for assessment of performance and cost effectiveness if only a portion of the fleet participates in the program, and there are no other differences between the two categories of vessels that would affect bycatch rates besides participating versus not participating in the fleet communication program.

There is a need to augment efforts to engage fishers to abate fisheries bycatch. Fishers are some of the most qualified people to develop and improve bycatch mitigation techniques. Fishermen likely have a large repository of knowledge and information related to bycatch, which can be tapped to contribute to finding effective and practical solutions. This has been demonstrated by successful collaborative research in U.S. Alaska demersal longline fisheries (Melvin et al. 2001), U.S. Hawaii pelagic longline fisheries (Gilman et al. 2003) and the three presented case studies of industry-lead voluntary fleet communication protocols. Fishermen and fisheries associations are encouraged to become active participants to address bycatch problems by participating in research and commercial demonstrations, implementing best practices, and supporting adoption of regulations based on best available science before restrictions, embargos, and possible closures are imposed on them.

Most countries with longline fleets have a low degree of political will to address the problem of incidental seabird mortality, and have scarce resources for enforcement of seabird conservation measures. Few national fishery management authorities have frameworks to manage some types of bycatch, such as interactions between seabirds and longline vessels (Brothers et al. 1999; BirdLife International 2003; FAO 2003). A bottom-up approach that fosters a sense of industry ownership for effective bycatch reduction methods, and concomitant voluntary compliance with legally-required use of these methods, is needed in these countries. In this way, industry develops a sense of ownership for these tools and supports their required use.

Instituting incentive instruments can augment participation by fishes to abate fisheries bycatch (Gilman et al., 2002). Incentive instruments include formal constraints through legally binding accords, laws, regulations, policies, and policing; eco-labeling; industry-self policing; bycatch fee and exemption structure (similar to a “polluter pays” system); and education (Gilman et al., 2002).

Solutions to marine fisheries bycatch, including the appropriateness and design of fleet communication programs, need to be tailored to specific fisheries. Different bycatch reduction methods may be appropriate for different fisheries due to differences in the bycatch species that interact with each fishery, vessel designs, fishing gear, and fishing methods (Brothers et al. 1999; Gilman et al., 2005a). A fleet communication program is likely an ineffective strategy to address a fisheries’ bycatch problem when the incidence of interactions with the bycatch species is a common event and occurs across the fleet’s fishing grounds, and in fisheries where there is a lack of economic incentives to reduce bycatch. And instituting a fleet communication program would be difficult in fisheries lacking sufficient onboard observer coverage, and in fisheries lacking a fishery association for large fleets. Therefore, broad assessments in individual fisheries must precede advocacy for uptake of specific bycatch reduction strategies.

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